Subdividing for Success?

The Farm Size-Productivity Relationship

in the South African Land Reform

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Preface

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All remaining inaccuracies and errors in this thesis are mine and mine alone.

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Summary

According to the hypothesis of an inverse relationship between farm size and land productivity, farm size can be an important determinant of success for the land reform farms in South Africa. The analysis in this thesis provides empirical evidence in the debate on whether the land reform should equalize the land distributions or keep the large-scale sector intact. A strong inverse relationship is found between farm size and land productivity indicating that small-scale beneficiaries in the land reform are more efficient than large-scale beneficiaries. Through indirect testing the result is attributed to intensive labour use and more extensive land use on small farms. The comparative advantage of the small-scale beneficiaries provides a strong argument to redistribute smaller holdings. This would increase output of land reform farms and probably absorb more labour, which will be a crucial contribution to alleviation of rural poverty and the success of land reform farms.

This thesis will first present the theory and discuss previous literature of the inverse relationship. Then I will use data on farms controlled by beneficiaries from a cross sectional data set from the Quality of Life survey (QoL) of 2005. Using Stata 10.0, the analysis starts with regressing farm size on land yield, defined as the value of output per land unit, which is the classical approach to test if there exists an inverse relationship between farm size and productivity.

The theory of the inverse relationship postulates that the use of cheaper family labour on small farms, is the source of the often observed relationship. The empirical analysis shows that there is indeed a negative relationship between farm size and land productivity among the beneficiaries of the land reform. This indicates that small farms are more efficient and that labour market imperfections are dominant. Critics of the above analysis assert that the observation of an inverse relationship is caused by unobserved land quality differences (Benjamin, 1995). However, when controlling for land quality and other variables that may bias the results the inverse relationship remains intact. To test if labour market imperfections are the reason for the results the analysis is redone only for large farms. If the results are caused by fam-

ily labour use on smaller farms the IR should become less significant since the entire range of large farms are to a larger degree dependent on hired labour (Bhalla, 1979). The results show that the relationship between farm size and land productivity is less significant for large farms, indicating that the intensive labour use on small farms is an important determinant of the observed inverse relationship. According to this analysis subdivision of land reform projects will increase output, more of the available land will be used and the projects will create more jobs in the agricultural sector. A relevant policy implication is that smaller land holdings should be made available on the market, and that subdivision of farms can indeed be a criteria for success in the South African land reform.

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1 Introduction

Since the fall of Apartheid land reform has been a major development policy in South Africa. Pre-apartheid policies led to a highly unequal land distribution based on race making the black rural population a poor lower class; 71 percent of poor households in South Africa are black rural people (Zimmerman, 2000). In this situation there is indeed a need for rural poverty reduction and redistribution of property rights. The main goals of the land reform are, apart from addressing historical injustices, rural poverty alleviation, economic growth, and redistribution of income (DLA, 1997). The land reform has so far been market led as the government provides grants to eligible beneficiaries to buy land in the market. However, the reform has shown little progress both in terms of the amount of land redistributed and the success of those who have received land through the reform (Lahiff, 2007). The initial target was to redistribute 30 percent of white owned agricultural land by 2009, but so far around 4 percent has been redistributed and the deadline has been moved to 2014. The farms that have been redistributed, called land reform projects, are to a large degree unproductive or have failed completely (Hall, 2008). Despite the lack of success, politicians seem devoted to reach the 30 percent target and there is a call for a radicalisation of the reform to speed up the process (Lahiff, 2007). Since the agricultural sector is the most important employer of the rural population and an important earner of foreign exchange (Lahiff, 2007; Hall, 2008), expanding the reform without the ability of the redistributed projects to engage in productive production could be devastating for the rural economy and the economy as a whole. A failing land reform could increase rural poverty and threaten job and food security, thereby causing opposite results than it was supposed to. Recognising the political and emotional importance of redistributing land in South Africa, as well as its economic importance, makes it important to evaluate the reform and identify criteria for success rather than rejecting it as a failure.

Economic theory recognizes land redistribution as a way to alleviate rural poverty and promote equality; land is the main asset in the rural sector for accumulating wealth and transferring it between generations (Deininger and Binswanger, 1999). There is also a strong argument that land reform could be efficiency enhancing, increase agricultural productivity and employment. At the centre of the argument is the so-called stylized fact in development economics of an inverse relationship between farm size and productivity i.e. the agricultural sector in developing countries appears to be scale inefficient (Banerjee, 2005). If this is true, there could be a productivity gain in redistributing land from large to small farms. The inverse relationship can be explained by imperfect information causing moral hazard problems; hired labour will have no incentive to work hard when not supervised properly (Binswanger and Rosenzweig, 1986). As large farms rely on hired labour that must be supervised, they face higher labour costs than small farms that rely on family labour. Large farms, either organized through private ownership, as a collective or under a sharecropping contract will face incentive problems and the inability of full supervision, which can lead to undersupply of effort and investment (Deininger, 1995). Small farms on the other hand use family labour with an incentive to apply optimal level of effort and investment since they receive the full return to their inputs. In this respect the land reform in South Africa seems to be counter intuitive. Policy makers have argued for the preservation of the large-scale commercial sector created under apartheid when designing the land reform and have restricted the subdivisions of farms (Lahiff, 2007; Hall, 2008). Under apartheid there were policies in favour of large mechanized white farms, which created an agricultural sector dominated by a white elite (van Zyl et al., 1995). The argument for restricting subdivision of farms is the existence of scale economies that farms under a "viable" economic size are not sustainable (Lahiff, 2007; Hall, 2008). Restriction of subdivision means that farms available on the market are relatively large and grant recipients have to pool their resources together in order to afford the land available. Others, on the other hand, argue that the main reason for the low productivity of land reform projects is the failure to subdivide, because eligible beneficiaries do not have the resources or the necessary skills to manage a mechanised commercial farm (Lahiff, 2007). Van den Brink et al. (1995) argue that the concept of a "viable" farm size is not based on economics of scale, but an illusion created by apartheid policies that made the small-scale sector unproductive for the reason to transform the small-scale black farmer into wage labour for the white land owner and the mining industry. It would be unfair to compare the potential of small-scale farming with a sector that has been discriminated for centuries.

The purpose of this thesis will be to examine if division of land reform projects into smaller units could be a criterion for success in the South African land reform. Lack of evidence from existing beneficiaries has so far made it impossible to analyse the efficiency and scale economies of the land reform. This paper uses data on farms controlled by beneficiaries from a cross sectional data set from the quality of life survey (QoL) of 2005 to investigate if there is an inverse relationship between farm size and land productivity for beneficiary farms. An inverse relationship implies that small farms use the available land more efficiently and produce more per unit of land.Then a redistribution of land into smaller holdings will be more efficient than keeping the current agricultural structure intact.

The analysis starts with regressing farm size on land yield, defined as the value of output per land unit, which is the classical approach to test if there exists an inverse relationship between farm size and productivity (Carter, 1984; Heltberg, 1998; Bhalla and Roy, 1988). The literature rejects that there are technical returns to scale in agricultural production (Binswanger and Deininger, 1993), and a relationship between farm size and value of output must then be attributed to market imperfections. Testing whether farm size has a significant impact on the value of output is seen as an indirect test for the presence of market imperfections that lead factor prices to be dependent on farm size (Bhalla and Roy, 1988). Small farms face lower labour costs, because they are primarily dependent on family labour. Family members that work on the farm are stakeholders and therefore have an incentive to work hard. Wage labour, on the other hand, will have no incentive to apply effort unless supervised (Binswanger and Rosenzweig, 1986). Larger farms face lower capital and land costs as land work as collateral and thereby reduce the cost of credit. A positive relationship between farm size and land yield means that larger farms face lower capital costs offsetting the supervision cost of labour. A negative relationship indicates that labour market imperfections are dominant that leads labour intensive small farms realising a higher land yield.

The empirical analysis shows that there is indeed a negative relationship between farm size and land productivity among the beneficiaries of the land reform. This indicates that small farms are more efficient and that labour market imperfections are dominant. Critics of the above analysis assert that the observation of an inverse relationship is caused by unobserved land quality differences (Benjamin, 1995). However, when controlling for land quality and other variables that may bias the results the inverse relationship remains intact. To test if labour market imperfections are the reason for the results the analysis is redone only for large farms. If the results are caused by family labour on smaller farms the IR should become less significant since the entire range of large farms are to a larger degree dependent on hired labour (Bhalla, 1979). Also noting that irrigation, which is the prime indication for the ability to use the land intensively (Bhalla, 1979), is positively correlated with farm size, the conclusion becomes that small farms apply more labour per land unit and are able to use the available land more extensively. According to this analysis subdivision of land reform projects will increase output, more of the available land will be used and the projects will create more jobs in the agricultural sector. The thesis ends with a plea to make smaller land holding available on the market.

The thesis is organised as follows. The next section outlines the evolution of the agricultural sector and land reform policy in South Africa. Section 3 describes the theory behind the empirical observation of an inverse relationship. Section 4 gives a review of the literature on the topic of the inverse relationship and discusses the main critique of the analysis used in this paper. The data is presented in section 5. In section 6 the econometric methods are discussed. Section 7 outlines and discusses the results, and finally section 8 concludes and summarizes.

2 The evolution of South Africa's rural sector

In 1994 the first democratically elected government of South Africa inherited one of the most unequal land and income distributions in the world; a white minority, 10,9% of the population, controlled 86% of total agricultural land while the African majority was confined to 13% of the territory known as the homelands. The black population also accounted for a disproportionate share of the poor (Lahiff, 2007). The agricultural sector was, and still is, separated by means of production as a highly mechanized commercial sector coexists with black small-scale subsistence oriented farmers. This distinct agricultural structure is not primarily a product of economies of scale or the abilities of the white farmer, but a consequence of decades of discriminatory policies, under the apartheid regime, explicitly made to make black small-scale farming unprofitable. The emergence of large-scale white farms was made possible by artificially depressed wages of black workers, the creation of marketing monopolies, direct transfers and output subsidies (Christiansen and van den Brink, 1995; Binswanger and Deininger, 1993; Bundy, 1988). In fact, during the 19th century the African tenant and owner-operated farms were outcompeting large-scale farms dependent on hired labour, operated by European settlers (Christiansen and van den Brink, 1995; Binswanger and Deininger, 1993; Bundy, 1988). The main reason for the comparative advantage of the African farmer was the simple technology and the large amount of labour used in production (Christiansen and van den Brink, 1995). In some sectors the large-scale settler farms were unprofitable and could not offer competitive wages to attract labourers from the small-scale sector. The white large-scale farm owners argued that labour shortage made it impossible to compete and lobbied for policies to curb competition from black farmers (Christiansen and van den Brink, 1995). Limiting access to output and input markets and restricting areas where Africans could own land effectively restrained African owner operated farming. As a result of the restrictions on farms owned by black Africans, tenancy became more pronounced, and at the end of the 19th century 50% of African farmers were tenants on white owned land (Christiansen and van den Brink, 1995). Under the tenant system, African farmers remained competitive and managed to accumulate wealth and skills, and became relatively affluent and independent, while South Africa's white farmers became the world leader in receiving government transfers (Christiansen and van den Brink, 1995). Concerns that the increased wealth of the African farmers made them difficult to govern and the sharp increase in labour demand from the emerging mining sector, led to an act that had profound impact on the South African history (Christiansen and van den Brink, 1995).

In 1913, the parliament of the then three-year-old Union of South Africa passed the Natives Land Act. It was the first major segregation legislation, which later set the premises of apartheid. The act formalized by law the borders of the African reserves and declared that natives, defined as members of an aboriginal race or tribe of Africa, only had rights to conduct agricultural activities within these reserves (Feinberg, 1993). Over two thirds of the population were natives and the reserves covered only 7,8% of agricultural land, and the act therefore aggravated the agrarian degradation and led to further congestion of the African areas (Christiansen and van den Brink, 1995). Agricultural land outside the reserves was reserved for whites, who represented less than a quarter of the population. Native Africans could not own, rent or lease land outside the defined areas, which later became known as the homelands or bantustans (Feinberg, 1993). This meant that Africans that did productive farming outside the reserves before 1913 lost all their land rights and were forced to move into the African reserves. Inside the reserves the natives had no land rights expect cultivation of the land, they were not allowed to mortgage, sell or freehold the land (Christiansen and van den Brink, 1995). The major motivation for the law was to transform African farmers to wage labour for the mining industry and white farms. Another factor was the wish to curb competition from black farmers and the racial ideology of keeping the African population under control (Binswanger and Deininger, 1993). Over the following century many other discriminatory policies were put in place and the result was to finally eradicate any form of productive small-scale sector in South Africa. The black rural population lost their agricultural capital, farming skills and information base that had been accumulated over generations (Christiansen and van den Brink, 1995). In this way the rural sector became dominated by highly mechanised white farms, despite the historical comparative advantage of labour-intensive production (Deininger and May, 2000). At a substantial cost, an advanced agricultural sector had emerged and became the most important employer of the rural sector. The natives land act was reversed in 1993 and the government elected in 1994 initiated a land reform programme to try to reverse some of the consequences of the apartheid policies, underpin economic growth, and improve household welfare (Deininger and May, 2000).

2.1 South Africa's land reform policy

The framework for the land reform policy in South Africa is laid out in The white paper for land reform (DLA, 1997). The reform is based on three categories, namely restitution, tenure and redistribution.

Restitution gives legal rights to people that had been forced off their land after the passing of the natives land act in 1913. People that were wrongfully evicted from their land are entitled to compensation either in kind or in cash (Hall, 2008). Tenure reform is aimed at providing all South Africans with secure property rights, and also recognises the legal rights of occupiers, either individuals or communities, on private land and state land (Hall, 2008). The redistribution component is to provide land for landless, labour tenants, farm workers, as well as new entrants to agriculture.

Redistribution is the most important component of the land reform as it is expected to make the most substantial contribution and benefit the greatest number of people (Lahiff 2007). The redistribution is based on the principle of "willing seller" and "willing buyer". This means that the seller and buyer engage in voluntary negotiations and the role of the state is to provide grants to eligible beneficiaries to be able to buy land in the market (Deininger, 1999).

Until year 2000 a one-time grant of maximum R1600[1] were made available for households earning less than R1500 a month (Lahiff, 2007). Restrictions on subdivision, as discussed below, and the relatively large holdings available on the market as a consequence of the policies described above, forced beneficiaries to pool resources together to be able to buy land. This resulted in the majority of the land reform projects being farmed collectively (Hall, 2008). The lack of success of the land reform projects up to year 2000 led to restructuring of the grant system to make it more focused on targeting emerging black commercial farmers and smaller groups. The income ceiling was abandoned and own contributions from the beneficiaries are required either in cash or in kind. The grants are given on a sliding scale depending on the size of the contribution made by the beneficiaries. This has raised the concern that the land reform is leaving the poor behind; as the grant system depends on the beneficiaries' own contribution it will target people with a previously strong asset base (Hall, 2008).

2.2 Restrictions on subdivision

The lack of smallholdings on the market is an obvious reason why a market led land reform is unable to subdivide large farms into small and medium size farms. The lack of small farms on the market is a consequence of the agricultural land act of 1970 that restricted agricultural land from being fragmented into "uneconomic units" (Hall, 2008). The land reform projects are in fact exempted from the act, however the market consisting of only potential land reform beneficiaries is too small for it to be profitable for large land owners to bear the cost of subdividing their land and selling it in multiple parcels (Lahiff, 2007). In this way the act indirectly restricts the opportunity of beneficiaries to buy small and medium farms. This is an important obstacle since small-scale land is the most sought after by the rural poor and landless (Lahiff, 2007). As outlined above the reasons for

[1] Rand (R) is the South African currency. 1 Rand was equal to NOK 0.75 in 2009 (NorgesBank, 2010)

restricting subdivision of agricultural land were to restrict the emergence of black small-scale farmers and, as noted by van Zyl et al. (1995), to secure a minimum income level for the white farmer. The land act was repealed in 1998, but has still not been signed into law by the President, it has been argued that this is a result of lobbying from commercial farmers (Hall, 2008).

Institutional and ideological obstacles have prevented subdivision of land reform projects after they have been acquired in the market (Hall, 2008). The major obstacle is the general scepticism among officials in central positions towards restructuring the agricultural structure. Land reform projects that propose to subdivide existing farm units or apply for grants to start small-scale production stand little chance of being accepted, even though the largest demand is for small-scale production (Lahiff, 2007). This scepticism is based on the belief that productive farming can only be conducted on large-scale farms and stems from the fact that a large part of the rural population has never seen a successful and productive small farm because of the distortions imposed under apartheid (Deininger, 1999). This has resulted in large land reform projects farmed by large groups expected to conduct commercial farming, usually based on the former use of the land, dependent on heavy equipment, market access, farming skills and credit supply (Lahiff, 2007). As argued by Lahiff (2007) beneficiaries have numerous problems accessing credit markets and lack of credit makes many of these land reform projects unworkable.

The commercial agricultural sector is highly technical, modern and a substantial employer while the current small-scale sector is relatively unproductive. The wish to keep the productive agricultural sector is therefore understandable. However, as discussed above, decades of discrimination of the black rural population has led to the loss of agricultural skill and capital and it may therefore be too optimistic to expect that beneficiaries can turn into commercial farmers overnight. Small-scale and medium-scale production may be a more efficient and productive approach, at least in the short run. Recognising these problems has led to a shift of focus to emerging commercial black farmers and businessmen, perhaps moving the land reform away from its goal of rural poverty reduction (Hall, 2008). The continuation of the focus on large-scale farming is likely to benefit a small group of privileged and may not be labour absorbing, which is crucial for combating rural poverty. To further examine whether it is warranted to keep the current large-scale structure intact to uphold the agricultural productivity, the next chapter will discuss the theory of economies of scale in agricultural production.

3 Theory

The central goals of the land reform in South Africa are the alleviation of rural poverty and a more equal distribution of assets. A general concern of the redistribution of income is that a more equal distribution of assets comes at the expense of economic efficiency. This seems to be a major concern for policy makers in South Africa, measured by their energy used in retaining the current agrarian structure by restraining subdivisions of large farms. This implies taking for granted that preservation of large mechanized farms is the best approach to uphold the agricultural output. Beneficiaries are forced to pool resources together and form large projects organised as cooperatives due to the limiting size of grants. Retaining large farms may have opposite effects on productivity if larger farms are associated with lower land productivity. In the case of land redistribution there is a theoretical possibility to have both economic efficiency and a more egalitarian land distribution. The inverse relationship between farm size and productivity is a stylized fact in development economics that postulates that small farms have higher land productivity than large farms. The argument is usually explained by comparative advantage of small-scale agrarian production; small farms produce more per land unit than large farms, thus land redistribution will alleviate rural poverty, promote equity and increase production as we have more output per unit of land on small farms (Heltberg, 1998).

3.1 The inverse relationship between farm size and output per land unit

There is a large amount of literature on the inverse relationship (IR), and several papers have concluded that there is a significant IR. Some of the literature is discussed below. The existence of an IR has usually been demonstrated by showing a significant negative relationship between output per land unit and farm size. According to Heltberg (1998) the economic causes for this relationship can be:

- Diseconomies of scale
- Small-scale farmers are more efficient
- Market failures that lead factor prices to be dependent on farm size

The literature on the topic has focused its attention on the last point, which will also be the focus of this paper. Firstly, there is no reason to believe that large-scale farmers should be less able to make efficient apportionment of their resources than small-scale farmers. Larger farms should also have easier access to inputs and credit, as will be explained below, so most likely larger farmers should be at least as efficient as beneficiaries on smaller farms (Bhalla, 1979; Heltberg, 1998). Secondly, there is widespread evidence on constant return to scale (CRS) technology in agricultural production (Berry and Cline, 1979; Bhalla, 1979; van Zyl et al., 1995; Heltberg, 1998)[2]

Assuming that we have CRS technology and that there is no reason to believe that small farmers should be inherently more efficient, according to standard economic theory there should be no relationship between farm size and output per land unit. At competitive factor prices and constant returns to scale, agents will choose optimal factor combinations at every production level. Since the IR is observed in conjunction with CRS technology, the determinant becomes the behavioural pattern of resource utilization by farm

[2]See especially Binswanger et al. (1994) for economies of scale in South African agricultural production.

size (Berry and Cline, 1979). Hence we should turn to asymmetrical market imperfections to explain the IR.

3.2 Market Imperfections Related to Farm Size

With CRS technology and rational farmers, as we assumed above, input ratios should be constant across farm scale, but if factor prices depend on farm size the input ratios will be distorted and could lead to a relationship between output per unit of land and farm size. A theory that incorporates this aspect is the dualistic model in the rural development literature (Binswanger and Rosenzweig, 1986). The model predicts that the agricultural sector is divided into two sectors based on size, a modern large-scale sector and a small-scale traditional sector. The modern sector consists of large-scale farms that are capital intensive and dependent on hired labour. The farms are commercial and they maximize profits so all factors of production are paid their marginal product. The traditional sector consists of small-scale farms with mostly family labour that use simpler labour intensive production techniques. Instead of maximizing profits the family farm maximizes output and shares the output/income between family members as they value income received by each member of the family. The dualistic structure has emerged because the modern sector faces higher labour costs, due to the assumed higher supervision cost of hired labour than family labour, and lower capital and land costs than the traditional sector. Therefore the modern sector will apply a lower labour/land ratio than the traditional sector and the effect on the capital/land ratio is ambiguous and depends on the proportional effect on land and capital prices as farm size increases (Berry and Cline, 1979).

The observation of an IR is attributed to the presence of labour market dualism that dominates market imperfections in land and capital markets (Bhalla, 1979). These market imperfections are further discussed in the next section. Ceteris paribus, the small-scale farms will have higher output per land unit than large-scale farms because when faced with lower labour costs they will apply significantly more labour per unit of land. They will thus be able to cultivate their land more intensively - the same piece of land is harvested several times in a given year, and more extensively - they cultivate a higher proportion of the land available to them. The lower capital costs facing large-scale farmers will somewhat offset the effect of more expensive labour. The effect on yield depends on two factors. First, which factor market imperfection is dominant, that is, which factor price is more sensitive to farm size. Secondly, it depends on the extent to which labour can be substituted by capital in production. This dualism, as the modern and traditional sector face different factor prices, can cause distortions in the agricultural sector's utilization of available land and labour resources (Berry and Cline, 1979). There will be large amounts of labour applied in the traditional sector as well as scarcity of capital and land, which will lead to very low marginal productivity of labour. The modern sector will have abundant holdings of land, leaving large amounts of the land unused (Cornia, 1985). This relationship is the fundamental rationale behind land reform. Redistributing underused land on large farms into smaller holdings will take advantage of the excess labour in the small-scale sector and increase agricultural output. This duality is a good description of the agricultural sector in South Africa, where large-scale highly mechanized farms driven by white farmers coexists with small-scale black family farms. This dual structure will be maintained as there are restrictions on subdivision of farms. To understand why and how market imperfections can be dependent on operational scale we will take a closer look at each factor market in turn.

3.2.1 Labour market imperfections

The small-scale traditional sector is characterized by vast amounts of labour, which means that labour can be removed from the traditional sector with very little or no reduction in production. This is called surplus labour (Ray, 1998). Since the marginal productivity of labour (MPL) is higher in the modern sector we should expect to see a relocation of labour until the marginal productivities are equalized. When we have a homogenous production function, as is assumed in agricultural production, the input ratios should also be equalized. There are three main reasons why this may not happen according to Bhalla (1979) 1) The supply price of family labour is equal to the average product 2) With unemployment the opportunity cost of family labour will be lower than the wage rate and 3) there are substantial real costs of hired labour besides the wage rate.

Family farms value positive income received by each member even though the MPL can be very low or even zero. To clarify, we can assume that each family labourer receives the average product per unit of labour on the family farm; the average product will then be the supply price of family labour that will be equated to the outside wage. The outside wage will be equal to the MPL on large-scale commercial farms; hence we will observe a higher MPL and a lower labour/land ratio on large-scale farms than on the family farm (Berry and Cline, 1979). To maximize the family income it would be rational to hire out family labour until the MPL is equalised between the sectors. One obvious reason why this may not happen is that the individual worker will lose; the individual worker will receive its marginal product on the large farm foregoing the higher average product on the family farm. On the other hand the family could compensate the family member that finds work elsewhere and thereby close the gap between the average and marginal product. This may not be possible if the family farms pay in kind and have little access to markets, and thus would not be able to compensate the worker if the job is in another area. Also with surplus labour it is possible that the market clearing wage is very low and can be close to the minimum nutritional need of a worker, making the family farm unwilling to supply family labour to the market (Berry and Cline, 1979).

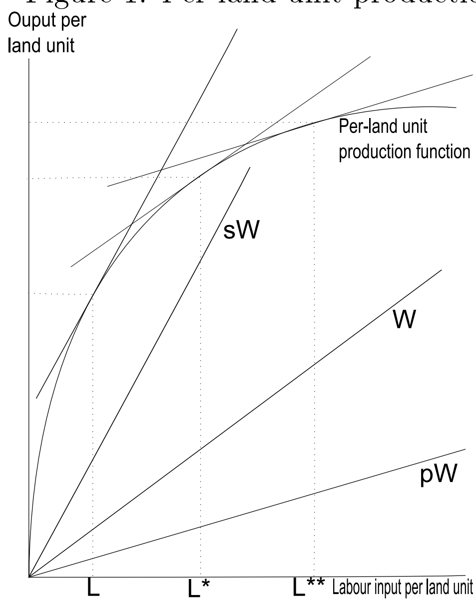
The opportunity cost of family labour is the remuneration that the unit of labour can get from working outside the family farms. With full employment the opportunity cost would be equal to the going wage rate, which is also the opportunity cost of hired labour. With unemployment[3] this will no longer hold (Hall, 2008). The opportunity cost of hired labour for the large-scale

[3] In 2008 The unemployment rate in South Africa was 28,8% (Fund, 2009).

farmer will still be equal to the going wage rate, but the opportunity cost of family labour will now be equal to the expected wage, since there is a probability of being unemployed. This means that the small-scale farmers will apply a higher labour/land ratio as they face a lower opportunity cost of labour. To see the argument more clearly a simplified production function depending on only labour and land, the market wage, w, and the opportunity cost of family labour, pw, are depicted in figure 1. The opportunity cost of family labour is the expected wage. As a simplification, assuming that the wage when unemployed is equal to zero, it is set equal to pw, where p is the probability of employment which is between zero and one. Assuming CRS technology the arguments are given in output per unit of land and labour input per unit of land. Both farms will apply labour until their respective opportunity cost of labour is equal to the value of marginal product. Assuming that the price is equal to unity, the large-scale farm will apply labour until the straight wage line W is tangent to the production function and the family farm will apply labour until the straight line pW is tangent to the production function.As we see in figure 1 the family farm will apply a higher labour/land ratio, L**, than the commercial farm, L*. This will result in, ceteris paribus, a higher output per unit of land than at the large farm.

There is an inherent incentive difference between family and hired labour (Binswanger and Rosenzweig, 1986). Family labour is residual claimant of the farm's output and will thus to a certain degree be fully awarded for their efforts. In an environment of asymmetric information moral hazard problems will arise that can substantially increase the cost of hired labour. Given that the landowner cannot easily observe effort - asymmetric information - workers on fixed wage contracts will have an incentive to shirk - moral hazard. There can be incentive problems within the household as well, especially for large families, but the incentive problem will always be less than for hired workers (Binswanger and Rosenzweig, 1986). Using a piece rate contract instead is not usually usable in agricultural production, since observing the output of a worker is not easy in both quantitative and qualitative terms (Binswanger and Rosenzweig, 1986). This means that hired labour must be supervised

Figure 1: Per-land unit production function



Source: Ray (1998)

directly to apply optimal amount of effort. The supervision costs that follow may be substantial, especially in agricultural production that is very spatially dispersed (van Zyl et al., 1995; Bhalla, 1979). The caveat is that supervision costs tend to be dependent on farm size. On family farms and small scale-farms that are mainly dependent on family labour, which can also perform supervision tasks without extra costs (Binswanger and Rosenzweig, 1986; van Zyl et al., 1995), the supervision costs are minimal, but as farm size increases and hired labour becomes dominant supervision costs will increase as well. In fact supervision costs are sufficient to make labour costs increase with farm size (Binswanger and Rosenzweig, 1986; van Zyl et al., 1995). This means that the larger farm size the higher labour costs, which explains the lower labour input per land unit on larger farms. This can be shown in figure (1), by simply assuming that large-scale farmers face an effective wage, sW, where s is the supervision cost that is larger than unity. This means that large-scale farmers face an effective wage that exceeds the market wage, and they will consequently apply L amounts of labour per land unit.

However, increasing labour costs with farm size is not sufficient for observing an IR (Bhalla, 1979; Heltberg, 1998). For instance, in the presence of the labour market imperfections explained above we should expect a reallocation of land through the rental or sales market until the output per land unit are equalised. Larger landowners will gain if they rent out parcels of land to small holders, and the smallholder will gain from renting the land, thus operational holdings should move towards a more optimal operational size (Binswanger and Rosenzweig, 1986). In order to observe an IR, we thus need to have market imperfections in at least two factor markets.

3.2.2 Land market imperfections

If it is possible to rent out land with a fixed rent contract, it would circumvent the moral hazard problems observed above. The tenant will receive the whole value of his effort and will thus apply optimal amount of effort. However if the tenant is risk averse and/or credit constrained the contract will not be accepted, and it will not be possible to offer an incentive optimal contract (Ray, 1998). Agricultural production is risky business; a storm can destroy a whole year worth of output (Bhalla, 1979), thus if the tenant is risk averse he needs to be compensated for the risk involved. In addition, if the tenant is credit constrained he will not be able to pay the rent before harvest, and only able to pay if the harvest is successful, thereby increasing the cost compared to owner operated holding. One option could be a risk-sharing contract, where the owner takes a part of the actual harvest. However, a sharecropping contract involves the same incentive inefficiencies as above. Since the tenant will not receive the whole benefit of the effort put into the farm, he does not have an incentive to use the efficient amount of inputs, which is known as the Marshallian inefficiency (Ray, 1998). This will limit the extent to which the rental market can equalize the land distribution since the expected return to self-cultivation is higher than the expected return from hiring out the land (Heltberg, 1998).

Heltberg (1998) gives four reasons why the land sales market is insufficient to reallocate land into smaller holdings. Firstly, land markets can be practically non-existent in some parts of the world, for example, there can be official polices that restrict the functioning of the land market. As previously discussed, for land reform beneficiaries there are institutional obstacles to subdivide land reform farms into smaller parcels and selling the parts on the market, making it impossible for a functioning land market to equalize land holdings. Secondly, small-scale farmers can be severely credit constrained making it impossible to acquire land at market prices. Beneficiaries get grants from the government to buy land, but as long as the farm sizes are kept intact, it will not make farm sizes smaller. Thirdly, historically it is observed that government interventions in input and output markets are biased towards large-scale farming. In South Africa the current agricultural sector has evolved after decades of government policies favouring large-scale farming over small-scale farming, and thus the available farms on the market are above average large and the land reform will only maintain the current structure. Finally, land holdings can also be seen as an asset for landowners both as collateral and for prestige purposes. This will tend to worsen the distribution of land and leave a large amount of agricultural land idle. Land market imperfections together with labour market imperfections are sufficient to induce an IR (Heltberg, 1998).

3.2.3 Credit market imperfections

Credit market imperfections are a source of another inverse relationship that can further skew the distribution of labour and land. There is likely to be an inverse relationship between the costs of capital and land and farm size. This is because land can be used as collateral; in the rural setting, land can be the most important asset and maybe the only form of collateral, and thereby reduce the cost of credit necessary to buy land and capital equipment. The large-scale farmer will have easier access to liquidity to buy machinery, invest in land improvements, high quality seeds and so forth (Binswanger and Rosenzweig, 1986). The large-scale farmer will tend to substitute the relatively expensive labour for the relatively cheaper capital and thereby exacerbate the difference in labour/land ratio between large and small farms. Whether higher capital input on large farms will increase the output per land unit compared to small farms depends on the relative decrease of land and capital prices as farms size increases, the substitutability between capital and land, and the substitutability between capital and labour (Berry and Cline, 1979). When we have a CRS production function depending on labour, capital and land, output per land unit will only depend on labour and capital input per unit of land. The effect of a lower price of capital and land on output per land unit will depend on the relative proportional decrease in the prices and also the substitution relationship. If land and capital are substitutes, cheaper capital will increase the intensity of capital and thereby counteract the lower labour intensity as farm size increases. The effect on output per land unit will then depend on the strength of the opposite forces. If we observe a negative relationship then labour market imperfections are dominant, and if capital market imperfections are dominant we would expect to see a increasing relationship between farm size and output per land unit (Bhalla, 1979).

4 Literature review

The empirical observation, through numerous studies, of a negative relationship between farm size and land productivity has become a stylized fact in development economics and a major argument for land reforms that equalize land distribution. The presence of an inverse relationship has usually been shown by finding a significant negative relationship between value of output per land unit and farm size in the following equation (Carter, 1984; Bhalla and Roy, 1988):

$$y_i = \beta_0 + \beta_1 h_i + \epsilon_i \tag{1}$$

where y is the log of land yield (value of output per land unit) and h is the log of farm size. The theoretical explanation is that factor prices are dependent on farms size leading to a difference in factor inputs between large and small farms. Whether farm size significantly influences land yield is seen as an indirect test for the importance of labour market dualism (Bhalla and Roy, 1988). Small farms face lower labour costs and will thus apply more labour per unit of land which will lead to the land being used more intensively and extensively, resulting in higher output per land unit than on large farms. The "stylized fact" remains highly controversial and contested. The main objection is the assumed exogeneity of farm size; if farms size is correlated with an omitted variable that explains output per land unit, the observed negative relationship, the coefficient in front of farm size, will be biased. The literature on the IR can be divided into early studies, where the negative relationship is observed, and later studies where the focus is on methods for securing the exogeneity of farm size.

4.1 Early Studies

A seminal work of Berry and Cline (1979) was one of the first studies to analyse the IR econometrically (Leiserson and Bhalla, 1979). They used cross-sectional data on two land abundant countries from Latin America and four land scarce countries from Asia - Brazil, Colombia, the Philippines, Pakistan, India and Malaysia. For all countries they regressed value of output per land unit on farm size finding a significant negative relationship between output per land unit and farm size. This is used as evidence of the superiority of small-scale farming and recognition of land redistribution as a way to achieve higher agricultural yields. To measure the effect of land redistribution they compare an estimated output per farm area with the actual average output per farm area for each country. The estimate is made by dividing the total farm land available by the total number of families in the rural labour force and using the estimated output per land unit on the resulting farm size. This gives an estimate for the post reform agricultural output per farm area. Out of this crude empirical exercise all countries analysed experience higher percentage output from the hypothetical land redistribution. The range is from a 10% increase for West Pakistan to a 28% increase for the land abundant country Colombia. This leads to the conclusion that there is a prospect for land reform for both land scarce and land abundant countries. Land abundant countries achieve an increase because a redistribution of land will lead to higher shares of land cultivated, while land scarce countries will achieve the same effects, but not as strong, because the cropping ratios will increase. For both types of countries this is possible because of the cheap labour faced by small farms, labour market dualism, which is concluded after observing a negative relationship between the labour/land ratio and farm size.

Cornia (1985) also recommends land redistribution in the presence of surplus labour; in an environment of surplus labour, land redistribution will achieve higher agricultural output, absorb labour, and alleviate rural poverty. The author falls to this conclusion after regressions of equation 1 using cross-sectional farm level data from 15 developing countries, and finding a significant IR for 12 of the countries. Three of the countries have insignificant results, which, according to the author, is because of a limited number of observations and scanty data. For the twelve countries with significant results the elasticity of land yield with respect to farm size ranges from -0.74 (for Uganda) to -0.18 (for India). All, except one elasticity that is significant at over 80% level of probability, are significant at over 90% level of probability. The elasticities for the land abundant countries are larger in absolute value. The significant IR is attributed to higher land use intensity on small farms, which is possible as they use both capital and labour more intensively, shown by finding negative labour and capital elasticities with respect to farm size. The negative elasticity of capital is as strong as the elasticity of labour in this study, but according to theory small farms should face higher capital costs than larger farms and capital use intensity will depend on the relative strength of the change in land and capital prices. This is explained by the author by the fact that the capital term used also contains capital equipment produced on the farm, which is higher on small farms because of the higher labour use, and that larger farms on average have lower capital/land ratio as a consequence of low rate of utilization of the farm area. The study is inadequate as it fails to control for land productivity; if larger farms are characterized by systematically lower land quality the observed IR will be overstated.

4.2 Is farm size endogenous?

As mentioned, if there is a non-random relationship between farm size and other variables that determine output per land unit, for example soil quality, irrigation, or product mix, the results will be biased and an observed IR can be attributed to some other exogenous variable. For instance, if soil quality is negatively correlated with farm size, i.e. larger farms have systematically lower soil quality than small farms, the observed IR can be a result of exogenous soil quality variables and land redistribution will not be efficiency enhancing. The exogeneity of farm size is the main theme in Carter (1984), Bhalla and Roy (1988), Benjamin (1995) and Heltberg (1998). Carter uses a panel dataset where each holding is observed at least twice over a 3-year period. Each holding is identified by its village location making it possible to use village fixed effects to control for intervillage differences in land quality. Heltberg (1998) expands the fixed effects approach by controlling for household fixed effects, which controls unobserved farm heterogeneity, using farm-level panel data from Pakistan. Bhalla and Roy (1988) use a cross-sectional dataset from India with detailed data on soil fertility for the observed farms. Benjamin (1995) asserts that regression of equation (1) suffers from omitted variable bias when land quality is unobservable which entails the necessity for using the instrumental variables estimator.

Both Carter (1984) and Bhalla and Roy (1988) use farm level data from India, but end up with widely different results, even though both papers find a highly significant IR when regressing equation (1). Carter expands the model by including a constant,α_i , for each village i in equation (1)

$$y_{ij} = \alpha_i + \beta_1 h_{ij} + \epsilon_{ij} \tag{2}$$

where y and h are land yield and farm size for holding j in village i. Assuming that the average soil quality within villages is relatively constant over the sample period,α_i, controls for land quality that is specific to each village. If the village specific land quality is not independent of the land distribution within each village, the estimate of β_1 in equation (1) will be biased. The hypothesis presented postulates that villages with high land quality will experience higher population growth, leading to a subdivision of land into smallholdings. Then village specific land quality will be negatively correlated with farm size and the IR would disappear or be diminished in equation (2). Carter finds that village specific effects explain a substantial amount of variation in land quality, but do not substantially diminish the IR observed in the original model.[4] Bhalla and Roy (1988) argue that the findings in Carter (1984) remain unconvincing because the data is from only one region in India and he lacks direct information on land quality. Bhalla and Roy (1988) first estimate a linear-log specification of equation (1) for seventeen states in India. This simple model finds a significant IR in 97% of the states. To test if the IR holds where the land quality is more homogenous the model is divided into 78 agronomic zones. In this model the significant IR drops to 69% of the states. The model is further expanded by including soil type, soil colour, soil depth and the fraction of irrigated land as control variables for land quality. In this case only 44% of the cases have an IR. To get even a greater homogeneity, controls for both climatic and soil characteristics are added and the model is divided into 176 districts. In this model only 29% of the districts have significant IR. The extensive measures used here to control for land quality show that the IR model can suffer from omitted variable bias, and show the importance of controlling for land quality. However, by dividing the sample into 176 districts to secure optimal homogeneity of land quality, the number of observations is substantially reduced for each regression. The authors recognize this problem and the minimum

[4] β_1 increases from -0,393 to -0.337, the change is not statistically significant.

number of observations were set to 40. Still, the lack of observations may have contributed to the declining significance of farm size in explaining land yield. Despite this objection the study shows the importance of controlling for land quality. It is rather rare to have detailed data on soil type, soil colour and soil depth, it is more usual to use indirect variables to control for land quality, as for instance the land's price, which will be discussed later.

Benjamin (1995) uses cross-sectional data from Java and finds a significant IR when using a model like equation (1). He then substitutes farm size with area actually harvested, arguing that farm size is only an imperfect measure of land input, and finds that the IR is still significant but diminished. The problem with this approach is that it eliminates the inefficiency of underutilizing productive land; if large farms use on average less of their available land that is suitable for cultivation then this is an inefficiency that should be accounted for. Berry and Cline (1979) note that it is perfectly consistent with the IR theory for the yield on area harvested to be higher on large farms than on small, because a smaller part of the available land is harvested on large farms. On the other hand, using farm size is imperfect as it also includes non-arable land, but this is solved in Berry and Cline (1979) by using land available for cultivation. The main point in Benjamin (1995) is that farm size in equations like 1 is endogenous when land quality is not included as a control variable. To correct for the bias various measures of population density, taking advantage of the hypothesis in Carter (1984) that higher population density should be negatively correlated with farm size, are used as instrumental variables to predict farm size. When predicted farm size is used as regression variable the IR vanishes, and it leads to the conclusion that the observed IR is due to unobservable variables. There are two major problems with this conclusion, which is also noted in Heltberg (1998). Firstly, the sample contains relatively homogenous farms, most farms are under 2 ha, so it is expected that the relationship is weaker. Secondly, the instruments used explain little of the variation of farm size; 0,14 is the highest R^2 obtained between farm size and its instruments, indicating that the instruments used may not be relevant for explaining farm size. If instruments are weak i.e.

they explain little of the variation in farm size, the instrumental variable estimator is no longer reliable (Stock and Watson, 2007).

To control for unobserved farm heterogeneity Heltberg (1998) uses a fixed effects model on farm-level panel data from Pakistan. He expands equation (1) by including a dummy variable for each farm and for each year in the sample period. The farm dummies will control for farm specific land quality that does not vary over time. The year dummies will control for factors that vary over time but not across farms, such as weather. The results strongly support the existence of an IR, indicating that farm specific land quality does not eliminate the existence of an IR. However, the model does not control for differences in land quality and other unobserved variables that are time variant, a concern also expressed by the author. Further finding that labour use significantly decreases with farm size, the observed IR is attributed to higher labour intensity on small farms.

4.3 Evidence from South Africa

As explained in the previous chapter the agricultural sector in South Africa is characterised by a large-scale commercial sector and a small-scale traditional sector. Van den Brink et al. (1995) point out that it would be unfair to compare the productivity of the commercial sector with the traditional sector because of the discriminatory policies against the latter. It has also been impossible to do so due to the general lack of data on the traditional sector. However, the authors refer to some case studies where black small-scale producers were not facing severe discrimination, and these studies concluded that small-scale farms were more efficient. Van Zyl et al. (1995) analyse the relationship between farm size and total factor productivity within the sectors instead of analysing between them. They find that smaller farms, in the commercial sector, are generally more efficient and that they use a relatively more labour intensive production technique. However, they find that farms in the former homelands seems to be scale inefficient, although the results should be treated with caution because all farms are relatively small. This result is not surprising, as it was a part of the Apartheid system to make small-scale farmers in the homelands unable to be self-sufficient so that they were forced to seek outside work (Deininger and May, 2000).

In the context of the current land reform the question of whether an IR exists in the South African agricultural sector is highly relevant. The available data makes it possible to undertake an empirical analysis, while keeping in mind the problems from previous studies. The data will be described in the next section. The econometric specification and suggestions for solving a potential endogeneity problem are discussed in section 6.

5 Data

The data used for the empirical analysis in this paper is a cross-sectional dataset from the Quality of Life (QoL) Survey made by the South African Land Reform Program in 2005. The dataset is explicitly collected for the purpose of monitoring and evaluating the land reform, and is described in May et al. (2008). The dataset includes observations from 2002 beneficiary households and is thus ideal for analysing the comparative advantage of small-scale compared to large-scale farms managed by beneficiaries, and whether this should have consequences for the land redistribution policies. The thesis is also to a minor degree based on qualitative data gathered on a field trip in South Africa with Julian May, professor in economics at the University of KwaZulu-Natal, and Henrik Wiig, researcher at NIBR, October 2009. The qualitative data are based on re-interviews of 16 projects from the original sample of the QoL data set.

Data was collected at the household level and at the community level[5]. The survey included a sample of beneficiaries, households and communities that have received land trough the reform, and an "identical" control group in order to do valid impact assessment analysis. However this is not relevant

[5]The following section is based on (May et al., 2008).

for the analysis in this paper and shall not be further dwelled upon. The sample includes 3716 households; 2002 households that have received land through the land reform (beneficiaries) and 1714 control households. My purpose in this thesis is to analyse if there exists an inverse relationship between land yield and farm size on the farms that are run by households and communities that have received land trough the land reform. Therefore only data from the beneficiary households and communities will be used in the analysis. The sample selection process follows a probability proportional to size technique; the selection probability for a project is proportional to its size. This is to ensure that households in larger projects have equal probability of being surveyed as households in smaller projects. Twelve households were then randomly selected within each project. The sample includes beneficiaries from all programs of the land reform, thus the sample should be representative of the population of eligible beneficiaries.

In the questionnaire respondents have listed all plots they have access to and classified them into one of four categories:

1. Private land, not part of the land reform
2. Project land, used individually, individuals retain output
3. Project land, used collectively, individuals retain output
4. Project land, used collectively, collective share output

The first category is private land that beneficiaries have access to outside the land reform. The next three categories are land that beneficiaries have gained access to through the land reform i.e. project land. Project land that is privately run falls under category 2. On this land individuals decide what to plant and when, provide all inputs, and receive all crops and profits. Category 3 is land where a group owns the land, decide what to plant and when, and provides inputs, but individuals provide labour and receive all output and profit. The last category is collectively driven plots where the group provides all inputs and shares all output and profits.

The purpose of the analysis is to investigate the relationship between farm size and land productivity, so the relevant observation unit will be farms consisting of plots that are classified into one of the four categories. This has been done by adding together plot characteristics within category 1 and 2 for each household, and within category 3 and 4 for each project[6] The data will then be on the farm level and each observation will be classified into one of the four categories that will represent the different farm types in this paper. An advantage of this approach is that it is possible to analyse the effect of the different organisational forms on land yield. Unfortunately, data on input use was not linked to the plots in the data collection and input use at the farm level is therefore not observed. This means that analyses of the differences in input use must be done indirectly, as shown in the results section.

After identifying observations with crop production and deleting extreme values, the sample contains observations from 571 farms. As much as 26% of the observations have missing values, but instead of deleting a substantial part of the data material, missing values were substituted by the mean from the available data. The advantages of mean substitution are that it keeps the mean of the sample intact, it is conservative, and it is the best guess without any further information (Fidell and Tabachnick, 2007). The major drawbacks are that the variance and the covariance of the variables will be deflated as more observations with mean values will decrease the variation of the sample. All regressions done below will be repeated with only the complete cases and if the results are similar, we can be confident in their predictions (Fidell and Tabachnick, 2007). The results for the complete cases are shown in appendix A. Summary statistics for all variables are included in table 1.

[6]For example, if a household has access to two private plots (category 1) and one project plot privately driven (category 2) then the size of category 1 plots are added together and the value of harvest are added together; these two plots then represents one privately driven farm. The category 2 plot represents one privately run project farm. The same is done for collective plots; if a project has access to two collective plots (category 4) then the size and value of output for the plot are added together and represent one collective farm.

Table 1: Summary statistics

Variable	Mean	Std. Dev.
Y	72539	463685
Yfs	12446	35530
Yop	25877	57951
Yland	207121	694056
Ylandop	271414	606400
FS	112.27	395.46
OP	46.27	188.307
I	0.060	0.22
N	571	

Y is the value of crop production[7], reported in Rands. Y is calculated by multiplying the harvest of each crop for the agricultural year of 2005 by their respective mean price. This implies assuming that there are no price differentials between farms i.e. that the "law of one price" holds within the survey. This is clearly not satisfactory since it is very likely that there is regional and local price differentiation due to quality differences between crops - non-homogenous products - and local market imperfections (Chavas and Aliber, 1993). It would have been an improvement to use region specific prices, thereby allowing price differentials at the regional level, however this was not possible due to data scarcity[8]. By using a monetary value of land quality as a control variable there is a correction of productivity differences due to price differences and the argument falls down to assuming fairly well functioning markets (van Zyl et al., 1995).

Farm size (FS) is the total size of the farm, denoted in hectares. Operated area (OP) is defined as the area used for crop production, denoted in hectares. It is equal to total farm size minus land that is not used for cultivation of

[7]There are 25 different crops cultivated by the beneficiaries, 67% of households reports growing more than two crop types and 20% grows more than four (May et al., 2008). The variable of interest here is the total value of crops harvested, so the composition of Y will not be of interest.

[8]With regional prices we would have no observations from Limpopo and Guateng provinces since there are no registrations of crop sales from these provinces. We would have no observations on private farms either, since the location of private farms is not registered.

crops. Yland is the value in Rands of the operated area. Ylandop is the value in Rands per unit of operated area. I is the proportion of operated land that is irrigated. As is seen in table 1 the mean of I is very low. The low means is partly because 719 of the farms, 93% of the sample, have no irrigation.

5.1 Advantages and disadvantages of the dataset

This paper tries to analyse whether small-scale farms that are part of the land reform have a comparative advantage in crop production. The great advantage, as previously mentioned, is that the data are on the beneficiaries, and should be a representative sample of the population of interest. This is a large survey with available data on several issues, however, a large survey increases the chance of data error, both due to inaccurate knowledge of the respondent and the increased difficulty of processing the large amount of data (May et al., 2008). A direct consequence of this is the large number of missing observations and extreme values. This makes the data cleaning process difficult and subject to uncertainty. Therefore the analysis is repeated including observations that were interpreted as extreme values in the main analysis. The results are reported in appendix A. A complete panel data set would have been advantageous as it would allow controlling for farm fixed effects such as land quality differences that are constant over time, ability of the farmers, and location. It would also allow controlling for unobserved factors that varies over time but not across farms, such as year specific weather conditions.

6 Econometric specification

To test the hypothesis of an IR in the South African land redistribution, I will use the described farm level data from farms that are controlled by land reform beneficiaries.

6.1 The classical IR model

The conventional approach to empirically test the IR is to use ordinary least squares (OLS) estimation on the following equation (Heltberg, 1998; Carter, 1984; Bhalla and Roy, 1988):

$$ln\frac{Y_i}{FS_i} = \beta_0 + \beta_1 lnFS_i + \epsilon_i \tag{3}$$

Y_i is the value of output for farm $i.FS_i$ is the farm size of farm i measured in hectares and β_0 is a constant term. The parameter of interest,β_1 , measures the elasticity of value of output per land unit with respect to farm size. ϵ_i is an error term that represents all other variables that determine land yield. The OLS estimator will be best linear unbiased (BLUE) if the following assumptions hold (Biørn, 2003)

$$E(\epsilon_i \mid FS_i) = 0 \quad \text{for} \quad i = 1, 2, \ldots, n \tag{4}$$

$$E(\epsilon_i \epsilon_j \mid FS_i) = \begin{cases} \sigma^2 & \text{for} \quad i = j \\ 0 & \text{for} \quad i \neq j \end{cases} \tag{5}$$

The first assumption implies that the correlation between the disturbance and farm size are uncorrelated and that the expected value of the disturbance term is equal to zero. The second assumption implies that the variances of the error terms are constant and equal to σ^2, i.e. homoskedastic errors, and that the disturbances from different observations are uncorrelated, i.e. no autocorrelation.

Equation (3) assumes that farmers have chosen optimal factor combinations and given CRS technology and identical factor prices for all farms, β_1 should be equal to zero (Bhalla and Roy, 1988). If β_1 is significantly different from zero there is an abnormality to explain. The impact of farm size on land yield is seen as an indirect test for the market imperfections explained above. If capital market imperfections dominate we will have high capital/land ratios on large farms offsetting the labour market imperfections and we should expect β_1 to be positive. If labour and land market imperfections are dominant there will be a tendency towards labour intensive small-scale farms that are able to use the available land more extensively and intensively than large-scale farms characterised with idle land. In this case we should expect β_1 to be negative and we have an IR (Bhalla, 1979).

The main objection to equation (3) is the assumption of exogeneity of farm size i.e. a violation of assumption (4). According to Bhalla (1979) assumption (4) holds if FS is independent of land quality, the proportion of the farm that is unusable land, and product mix.

6.2 Extending the model

We have omitted variable bias when an omitted variable is correlated with an explanatory variable, FS in model (3), and explains part of the dependent variable, land yield in model (3). In the presence of omitted variable bias assumption (4) is violated and the OLS estimate $\hat{\beta}_1$ will be biased. This is because FS will take credit for some of the variation in the dependent variable that is attributable to the variable left out of the analysis (Kennedy, 2007). The direction of the bias will depend on the correlation between the error term and FS; if an omitted variable is positively correlated with land yield and negatively correlated with farm size, $\hat{\beta}_1$ will have a downward bias. One solution to the problem is to include the problem variables as controls into the analysis. Then equation (3) becomes

$$ln\frac{Y_i}{FS_i} = \beta_0 + \beta_1 lnFS_i + \gamma' X_i + \epsilon_i \tag{6}$$

where γ' is a row vector of coefficients for the column vector of control variables X_i . This is a multiple regression model and the following assumptions must hold for the OLS estimator to be BLUE

$$E(\epsilon_i \,|\, FS_i, X_i) = 0 \quad \text{for} \quad i = 1, 2, \ldots, n \tag{7}$$

$$E(\epsilon_i \epsilon_j \,|\, FS_i, X_i) = \begin{cases} \sigma^2 & \text{for} \quad i = j \\ 0 & \text{for} \quad i \neq j \end{cases} \tag{8}$$

In addition, the regressors cannot be linearly dependent i.e. no perfect multicollinearity (Biørn, 2003).

6.2.1 Land unsuitable for cultivation

A concern is that the existence of large farms is due to the fact that they are situated in remote areas where there is no real basis for agricultural production.[9] One hypothesis is that areas with a high proportion of land that is unsuitable for agricultural production would experience low population growth and less pressure for subdividing land holdings (Carter, 1984). If larger farms have a higher proportion of unusable land the value of output per land unit will be understated as the variable FS incorporates the whole spectre of land types. Then if the relationship is non-random, i.e. the proportion of unusable land increases as farm size increases, β_1 will have a negative downward bias. The easiest way to control for unusable land, according to Bhalla (1979) is to replace FS in equation (3) with operated area OP, which is the land used for cultivation. This gives equation (9)

$$ln\frac{Y_i}{OP_i} = \beta_0 + \beta_1 lnOP_i + \epsilon_i \tag{9}$$

β_1 is now the elasticity of land yield with respect to operated area, a negative value will, of course, also here imply an IR.

[9] For instance, a 258-hectare large land reform project interviewed on the field trip had only 4 hectare of usable land.

6.2.2 Land quality

The main objection to both equation (3) and (9) is that if larger farms are characterized by systematically lower land quality this feature explains the IR. Such a relationship will cause a downward bias on $\hat{\beta}_1$. A hypothesis repeated in previous literature that may explain a non-random relationship between farm size and land quality is that larger farms are put together of low quality parcels from small farms. This is caused by distress sales by credit constrained small farmers that first and foremost will sell the part of their land that is of lower quality (Bhalla and Roy, 1988). Therefore a study that uses land yield as a dependent variable should incorporate land quality into the analysis (Bhalla, 1979).

The best method to control for land quality would be to have information on soil type, soil colour and soil depth, variables that directly explain land quality, but the lack of these variables necessitates the use of a proxy variable. The principal indicator of land quality is the price of land that should both reflect inherent quality differences and location of the land (Berry and Cline, 1979). There are two problems of using land price as a proxy for land quality. First, if the price not only reflects quality differences, but also reflects expected output that is based on previous realised yields, then the land price will depend on the expected land yield and this would lead to correlation between the error term and land price. Secondly, the land price as a quality term may be biased in favour of small farms. If there are more potential buyers for smallholdings the land price per hectare will then be higher for small farms than for large farms creating an illusion of higher quality land on small farms. These two effects work in opposite directions and may balance. Either way, leaving out a control variable for land quality can bias the results, so using the land price and assuming that the price mainly reflects land quality differences is defendable (Bhalla, 1979). Equation (10) incorporates the land price per operated area as a control for land quality

$$ln\frac{Y_i}{OP_i} = \beta_0 + \beta_1 lnOP_i + \gamma_1 lnQ_i + \epsilon_i \tag{10}$$

Q is equal to the value of land per hectare of operated land, γ_1 will be the elasticity of land yield with respect to land quality. This means that a 1% increase in Q will lead to γ_1% increase in land yield holding operated area constant. β_1 is the percentage change in land yield when operational area increases with 1% holding land quality constant.

An important determinant of land yield is the availability of irrigation. Irrigation makes it possible to have a higher cropping intensity and also to have production during the dry season. If small farms have a higher proportion of irrigated land than large farms, then this will also cause a downward bias on β_1, and possibly an observed IR can be the result of higher land area under irrigation for small farms. To control for the irrigation effect on land yield the variable I will be introduced as the proportion of cultivated area under irrigation in equation (11)

$$ln\frac{Y_i}{OP_i} = \beta_0 + \beta_1 lnOP_i + \gamma_1 lnQ_i + \gamma_2 lnI_i + \epsilon_i \tag{11}$$

In Bhalla (1979) model (11 is seen as an extreme test of the IR as the question to be asked is why small-scale farmers irrigate more of their land than large-scale farmers. Then if model (11) drastically alters the conclusions for the precedent models, the question that needs to be asked is why irrigation is disproportionally distributed along the production scale.

6.2.3 Product mix

Another feature that may cause a downward bias on the relationship between land yield and farm size is if large farms systematically cultivate low valued crops that need more land and less of the relatively expensive labour per unit of output. One way to control for a supposed shift in product mix as farm size increases is to regress the above models within a crop sector, for example to analyse the models only for farms producing maize. The data used here is not suitable for separating farms into different sectors as

67% of all households have reported to produce more than two crops (May et al., 2008). Even if it was possible to separate farms into different sectors it may not be the best approach since crop mix itself can be a response to the discussed market imperfections (Benjamin, 1995). Holding product mix constant will neutralize the inefficiencies caused by large farms shifting to crops that need less labour and more land which gives low values of output per land unit.

Berry and Cline (1979) argue that equations (10) and (11) are a more accurate way to control for the shifting of product mix. The argument is that evaluating the value of output achieved relative to available land and controlling for land quality leaves no reason to believe that there should be a systematic difference in cropping patterns between large-scale and small-scale farms. Keeping unusable land and land quality constant farmers independent of scale will choose the product mix that maximizes value of output per land unit. If there are market imperfections that lead large farms to shift to crops that are less intensive in the relatively more expensive inputs and give low value of output per land unit, the land will not be used to its full potential. This is an inefficiency that should be captured in the model.

6.2.4 Organisational form

> *"How do you organize 100 people?" A manager of a land reform farm cooperative used this rhetoric question to answer why a 94-hectare large farm is only using 19 hectares for production. He further explains that they were originally five brothers with families that applied for grants to buy a farm but the application was allegedly denied because they were too few potential beneficiaries. After they managed to get together a group of 100 people with more or less loose connections the application was granted.*

This is one of several similar stories told by land reform beneficiaries when they were interviewed in October 2009. This story gives reasons to suspect that there may be a relationship between organizational form and farm size.

Restrictions on subdivision of farms, relatively large farms on the market, and the small size of grants may have forced beneficiaries to form groups to be able to acquire farms through the land reform. These groups seemed to have major management problems and conflicts relating to investment decisions and the division of the workload. As larger farms are more expensive there is a chance that a higher proportion of large farms will be organized as collectives. Depending on the efficiency of different organizational forms can this cause a bias on the estimated elasticity in the models presented above. (Deininger, 1995) argues that agricultural collectives are far less efficient than independent family farms because members of collectives will not face the full reward of their actions and this will lead to undersupply of effort and investment. If this is true and a higher proportion of large farms in the sample are organised as collectives then this could lead to downward bias on $\hat{\beta}_1$. On the other hand Platteau (1995) claims that some forms of cooperative land management are superior to private farms. It is further argued that for sub-Saharan Africa this applies to community farms with communal property rights to agricultural land. Indigenous communities gaining property rights to land that is historically viewed as communal land may have well developed community institutions, organisational policies and trust amongst community members. This may enable them to pool their resources together, efficiently divide the workload and have a greater scope of labour specialisation. To control for organisational form I have included dummies for category 1,2 and 4 into equation (11).

$$ln\frac{Y_i}{OP_i} = \beta_0 + \beta_1 lnOP_i + \gamma_1 lnQ_i + \gamma_2 lnI_i + \gamma_3 Dpri + \gamma_4 Dpriprj + \gamma_5 Dcoll + \epsilon_i \tag{12}$$

$Dpri$ is the dummy variable for privately run farms, it takes the value of one if farm i is privately run and zero otherwise.$Dcoll$ and $Dprjpri$ is defined likewise respectively for collectively and private run project farms. A dummy for category 2 is omitted to avoid perfect multicollinearity. γ_3 is then the average difference between private farms' and category 2 farms' log of land yield, keeping operational size, land quality and irrigation constant. There are similar interpretations for γ_4 and γ_5. Equation (12) also gives a formal test of the claim given in Deininger (1995) that large farms, either organised privately or collective, will face the same problems that lead to an inverse relationship, since β_1 now reflects the land elasticity with respect to operational area keeping organizational form constant. The result of the econometric analysis are presented in the next section.

7 Results and discussion

Five models were estimated, based on equations (3)- (12), respectively. The results for model 1-5 are presented in column 1-5 in table 2. The regression of model 1 gives a highly significant negative estimate of β_1 equal to -0,77 which means that a 1% increase in farm size will on average lead to a 0,77% drop in land yield. The R^2, which in this simple model is equal to the squared of the correlation coefficient between land yield and farm size, is equal to 0,49. Without attracting too much attention to this measure it seems that farm size can explain a substantial part of the variation in land yield. If farm size is independent of exogenous factors that explain land yield the negative coefficient will reflect difference in input intensities leading to more intensive and/or extensive land use on small farms. Subdividing farms in the land reform into smaller holdings would increase agricultural output and if the IR is a result of intensive labour use of small farms, as theory postulates, it would also increase labour demand.

Replacing farm size with land suitable for cultivation to control for non-arable land the results remains practically unchanged. This implies that there is no reason to believe that larger farms should have a larger proportion of unusable land. In any case operational area will be used in subsequent models, as it is land yield from crop production that is to be explained.

Introducing a control variable for land quality should, as explained above, control for shifts in product mix and a non-random relationship between

Table 2: Regression results for log of land yield

Variable	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**
$\ln FS$	-0.773				
	(-21.51)***				
$\ln OP$		-0.714	-0.614	-0.638	-0.691
		(-21.08)***	(-13.26)***	(-13.52)***	(-14.37)***
$\ln Q$			0.177	0.17	0.157
			(3.12)***	(2.99)***	(2.83)***
DI				0.995	0.18
				(2.35)**	(0.459)
$Dpri$					-0.31
					(-0.33)
$Dprjpri$					0.21
					(0.22)
$Dcoll$					1.596
					(1.64)
R^2	0.486	0.476	0.487	0.493	0.513
$adj.R^2$			0.484	0.489	0.507

t-statistics in parentheses

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Constant term included, but not reported

farm size and land quality. The elasticity drops to -0,614 but is still highly significant. This implies that large farms are characterized by on average lower land quality than small farms, and that the consequent shift in product mix and lower land quality can explain some of the observed IR in model 1 and 2.

Model 4 controls for differences in land quality due to irrigation. Previous studies have used the proportion of arable land that is irrigated. Here a dummy variable is used because as much as 93% of the observations have reported no irrigation, observed as zero, and over 50% of the observations have full irrigation so the continuous variable acts almost like a binary variable. As we see in column 4 the coefficient in front of the irrigation dummy is positive and significant at the 95% level. The land yield elasticity with respect to operational size increases slightly, which implies in fact that the proportion of irrigation increases with farm size.

The last model incorporates dummies for organisational forms. The coefficients are relative to category 3. None of the coefficients for organisational form are significant and thus seem not to be a determinant of land yield. The observed negative coefficient for operated area in the previous models is kept intact implying that the IR is not dependent on organisational form.

7.1 Interpretations of the results

As previously explained a negative relationship between operational size and land yield implies that labour market imperfections lead small farms to apply a higher labour/land ratio and thus have the ability of having multiple cropping ratios and/or use a larger part of the available land. Lack of farm level data on labour inputs prevents a direct test on the IR between labour use and farm size. An indirect test for labour market dualism suggested by Bhalla (1979) is to regress model 3 and 4 only for large farms. If labour market imperfections are the reason behind the observed IR we should expect the relationship between land yield and operational scale to be non-existent for large farms that are completely dependent on hired labour. The problem is to know at which operational scale family labour input becomes negligible. I will use the same approach as (Bhalla, 1979) and regress model 3 and 4 for farms larger than 12 hectares. Although family labour can still be an important input for some range of the farms above 12 hectares, we still expect the IR to become less significant as farms larger than 12 hectares should to a higher degree be dependent on hired labour.

As we see in table 3 the relationship between land yield and operated size is insignificant. Incorporating irrigation we see that we cannot reject that $\hat{\beta}_1$

Table 3: Regressions results for farms>12 hectares

Variable	Model 3	Model 4
$\ln OP$	-0.24	-0.5
	(-0.87)	(-1.77)*
$\ln Q$	0.33	0.32
	(2.65)**	(2.61)**
DI		2.48
		(3.31)***
$adj.R^2$	0.061	0.126

t-statistics in parentheses

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Constant term included, but not reported

is different from zero at the 5% level of significance confidence level, but the null hypothesis is not rejected at the 10% level of significance. This supports the hypothesis that small farms experience higher land yield than large-scale farms because they apply labour more intensively. Another interesting observation is that irrigation, the prime indicator of intensive land use (Bhalla, 1979), is positively correlated with farm size indicating that the higher land yield realised on small-scale farms comes primarily from intensive labour use and extensive land use. This implies that small-scale farms are able to cultivate more of the land available than large-scale farms, and that large farms will be characterised by a higher proportion of idle land. This is supported by the qualitative data, where substantial parts of the observed large-scale farms are left idle.

7.2 Robustness and validity of the results

As noted several times the main objection to the analysis presented above is the assumption of independence of operated area from land quality. If value of land, used as a proxy for land quality, does not fully reflect differences in land quality and if larger farms have inferior land quality, the observed IR is overstated or worse may cause the IR. The only way to be sure that land quality is not causing a biased estimate is to include a variable for individual farm quality (Benjamin, 1995). The consequence of lacking information on soil fertility and the mentioned problems of using land value as a proxy for land quality is that we cannot fully exclude land quality as an omitted variable. Another objection to the relevance of the above analysis is that the method is only partial in the sense that it only assesses the use of one factor of production -land- as a measure of efficiency. As noted and stressed in Van Zyl et al. (1995) it is total factor productivity (TFP) that is the relevant measure of efficiency. TFP evaluates the opportunity costs of all inputs used in production relative to the output produced. The ability to compare TFP on farms depends on the availability of detailed data on input use for each farm. The lack of information on input use at the farm level makes this analysis impossible to conduct. Even with complete information on input use, TFP is difficult to calculate as a large part of the theory rests on the assumption of the use of surplus labour, with little or no opportunity cost, on small farms. There is no comparable wage for surplus labour so the social cost of its use needs to be imputed. An example is an exercise in (Bhalla, 1979) where the TFP at one extreme is first calculated with zero opportunity cost for surplus labour based on the Lewis assumption for surplus labour. Further the TFP is calculated with successively increased opportunity cost from $\frac{1}{2}, \frac{3}{4}$ of the market wage to the other extreme where the opportunity cost is increased to the full market wage. Under the assumption of zero opportunity cost TFP uniformly declines with farm size. The intermediate results confirm that smaller farms have higher TFP. When the surplus labour is evaluated at full market wage there is only a decline for farms over 15 hectare. These results are consistent with theory; small farms use cheap labour and little land while large-scale sector have abundant land and dependent on expensive capital.

Although theory predicts that TFP should be decreasing with farm size, it should not be taken for granted, with available data a comparison of TFP across the production scale should have been included. Although a non-decreasing TFP as farm size increases should not lead to a conclusion that an IR is non-existent, the above analysis is still meaningful, especially in the case of land reform. As pointed out by Berry and Cline (1979) TFP is not only the relevant measure of efficiency. If the goal is to maximize output then TFP is the relevant efficiency criterion, but if some weight is given to income distribution, poverty alleviation and labour absorption the highest TFP may not maximize social welfare. These criteria are important goals for the land reform, and the partial analysis can safely be granted some relevance.

As a control for the above results I have redone the analysis for land reform projects - farms that have been redistributed through the reform - leaving out the private farms form the sample. This is just to ensure that the results are not dependent on the observations from small private family farms and that the results are directly transferable to redistributed farms. The results are presented in appendix B, and a part from fewer observations they do not alter the conclusions.

8 Conclusion and policy recommendations

This paper shows that it would be favourable for the land reform in South Africa to take a new direction and equalise the land distribution. This conclusion is based on the observation that there is a significant negative relationship between land yield, defined as the value of crop production per land unit, and both farm size and operated area for beneficiary farms. This indicates that small-scale beneficiaries are more productive than large-scale beneficiaries. The results are still significant after controlling for land quality, product mix, fallow land and organisational form, underlining the conclusion that smaller farms are more productive. The analysis exploits the fact that if the observed IR is a result of labour market imperfections the IR should become less significant for large farms. This is because variation in land yield due to the difference in family labour input should be less influential for large farms that to a higher degree are dependent on hired labour. The results further show that the inverse relationship is less significant for larger farms indicating that the observed inverse relationship is due to labour market dualism. Irrigation, which is the prime indicator for the possibility of multiple cropping ratios (intensive land use) during the agricultural season, is positively correlated with farm size. This indicates that the difference in land yield does not come from more irrigation on small farms, but as a result of more extensive land use on small-farms. The main conclusion drawn from the analysis is that small-scale land reform projects use more labour per land unit and thereby have the opportunity to cultivate and harvest a larger proportion of the available land than large-scale land reform projects. This indicates that subdividing larger holdings will increase land use, output and absorption of labour, which are all important factors of the goals of the land reform. The results provide a strong indication that the subdivision of large farms is a criterion for success of the land reform. Possible explanations of the results may be that the factors that can lead to external economies of scale in agricultural production - skill, access to credit and markets - are to a certain degree absent for the population the land reform is trying to target. This makes small - and medium-scale production more successful.

However, the conclusions should be treated with caution. An indirect test of labour market imperfections is only secondary to direct observations on input use. A second weakness of the analysis is the use of land price as an indicator of land quality, especially since the main objection against the IR hypothesis is that unobserved land quality obscures the observed relationship between land productivity and farm size. An improvement, and suggestion for further research, could be an analysis of panel data, controlling for fixed effects, as well as the inclusion of soil fertility data.

Nevertheless the results from the econometric analysis and the qualitative data support the hypothesis of an inverse farm size - productivity relationship. All of the projects visited had idle land and the majority of the beneficiaries reported serious cooperation problems. This gives entitlement to repeat the policy recommendations given in Binswanger and Deininger (1993), a paper written before the land reform program was initiated. It gave a strong plea for the necessity for land reform in South Africa and outlined a plan for action where they recommended the following: "By (the beneficiary group) having the freedom to choose their farms, internal management schemes, and subdivisions, they can select locations and farming systems most appropriate to the capital and skill endowments of their members" (Binswanger and Deininger, 1993).

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9 Appendix A

A major problem with the dataset is that a substantial number of observations had unrealistic high yield values and high land values per operated area. For instance, 3% of the observations have value of output per hectare above R10 million, which is approximately equal to 1,21 million US 2008 dollars (Norges Bank, 2009). This may be due to measurement error, data entry error or inaccurate information from the respondents. Deleting these extreme values is of course not an optimal solution to the problem, but the data does not contain sufficient information to impute values where the values recorded are obviously errors. However, the results from the analysis of the original data set in table 4 show that the data cleaning process does not significantly alter the conclusions. This implies that the results are robust to errors in the data cleaning process.

Table 4: Regression results for log of land yield for complete cases

Variable	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**
$\ln FS$	-0.753				
	(-21.62)***				
$\ln OP$		-0.685	-0.44	-0.48	-0.567
		(-19.61)***	(-7.65)***	(-7.90)***	(-8.78)***
$\ln Q$			0.33	0.32	0.30
			(5.09)***	(4.82)***	(4.55)***
DI				1.124	0.688
				(2.16)**	(1.29)
$Dpri$					-0.60
					(-0.58)
$Dprjpri$					0.31
					(0.30)
$Dcoll$					1.53
					(1.42)
R^2	0.45	0.421	0.4594	0.469	0.49
$adj.R^2$			0.457	0.465	0.485

t-statistics in parentheses.

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Constant term included, but not reported

10 Appendix B

Table 5: Regression results for log of land yield for land reform projects

Variable	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**
$\ln FS$	-0.73				
	(-12.96)***				
$\ln OP$		-0.63	-0.59	-0.62	-0.68
		(-11.46)***	(-8.29)***	(-8.24)***	(-8.55)***
$\ln Q$			0.063	0.05	0.046
			(0.71)	(0.64)	(0.55)
DI				0.51	0.15
				(1.05)	(0.55)
$Dpri$					
$Dprjpri$					-1.06
					(-2.19)**
$Dcoll$					-0.713
					(-0.81)
R^2	0.389	0.335	0.336	0.339	0.35
$adj.R^2$			0.331	0.332	0.34

t-statistics in parentheses

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Constant term included, but not reported